Stock Annex: Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)

Stock-specific documentation of standard assessment procedures used by ICES.

Stock	Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea) (her.27.25-2932)
Working Group	Working Group on Baltic Sea Fisheries (WGBFAS)
Created	
Authors	
Last revised	March 2020, further modified in April 2021
Main revision	The Inter-Benchmark Process (IBP) on BAltic Sprat (*Sprattus sprattus*) and Herring (*Clupea harengus*) (IBPBASH, ICES 2020) was held in March 2020 to include **new estimates of natural mortality** (M) from the WGSAM 2019 Baltic Sea SMS keyrun (ICES, 2019). **New reference points** were calculated based on the new stock assessment results.
Last revised by	(WGBFAS/Tomas Gröhsler)

A. General

A.1. Stock definition

The stock comprises mainly spring-spawning herring and a small autumn-spawning population. Spring-spawning occurs at the coast with a temporal gradient from south to north. After spawning, individuals migrate to the deep basins for feeding. In addition, migrations between subareas of the Baltic have been observed (Aro, 1989). Since 2005, the stock has been managed together in units SD 25–27, 28.2, 29 and 32 (EC and Russian quotas).

A.2. Fishery

A.2.1 General description

Pelagic stocks in the Baltic Proper (subdivisions 25–29, 32) are mainly taken in pelagic trawl fisheries, of which the majority take herring and sprat simultaneously. But coastal gillnetters and purse-seine fisheries targeting herring for consumption also exists. The estimates of pelagic catch compositions are based on logbooks and landing declarations. Discarding at-sea is not considered to be a problem for this stock. The major part of the catch is historically taken by Sweden, Poland, and Finland. Landings of central Baltic herring caught in the Gulf of Riga are included in the assessment.

A.2.2 Fishery management regulations

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A.3. Ecosystem aspects

Drastic changes in the weight-at-age (WAA) of herring have been observed since the late 1980s (Parmanne *et al*., 1994; Cardinale and Arrhenius, 2000). A decrease was observed in almost all age groups and in all open areas of the Central Baltic, with the exception of the most northerly (Cardinale and Arrhenius, 2000). The low WAA has had dramatic effects on the biomass and the catches of herring. Additionally, the poor condition of the fish (i.e. low fat content) has important implications on the marketing for human consumption (Raid and Lankov, 1995).

Three different hypotheses have been put forward to explain the decrease in WAA of Baltic herring, which include (i) a reduction in selective predation of cod on smaller herring (Sparholt and Jensen, 1992; Beyer and Lassen, 1994), (ii) an influx of slow-growing individuals from the northern areas, and (iii) a real decrease in growth rates due to changes in stock size and feeding environment.

The latter hypothesis has been also supported by Flinkman *et al*. (1998) showing changes in WAA in the Northern Baltic to be related to the mesozooplankton species composition. For the Central Baltic, Horbowy (1997) modelled growth of herring in relation to the biomass of *Mysis mixta*. Similarly Szypula *et al*. (1997) stressed the importance of the macrozooplankton fraction in the diet of planktivores. Other studies have shown the importance of the copepod *Pseudocalanus* spp. for nutrition of Baltic herring (Davidyuka, 1996; Möllmann *et al*., 2003). Low salinity conditions have negatively affected the stock development of this copepod (Möllmann *et al*., 2003), which is the most important food item for open-sea herring in spring. The increased competition with the sprat stock has been indicated as another crucial factor in the decrease of herring growth, operating via top–down regulation and density-dependent mechanisms (Cardinale and Arrhenius, 2000; Casini *et al*., 2006).

B. Data

B.1. Commercial catch

The sampling for age composition is considered adequate. Most countries provide age composition of their major landings (landed in their waters by quarter and Subdivision). The landings for which age composition was missing represented about 15% of the total landings in 2011. Denmark, Sweden, and Poland use fisheries-independent sampling to estimate the landing figures for herring and sprat from trawl fisheries. In this fishery, the logbook data may not be sufficient and the sampling is used to increase accuracy in the input data.

B.1.1. Landings data

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B.2. Biological sampling

Weight-at-age in the stock is assumed to be the same as weight-at-age in the catch. No survey information from the first quarter is available, which could be used as the mean weight in the stock.

The proportion of natural mortality before spawning (Mprop) is set at 0.30 and the proportion of fishing mortality before spawning (Fprop) is set at 0.35.

B.2.1. Maturity

The proportions mature at-age were 0 for age 1, 0.7 for age 2, 0.9 for age 3 and 1 for older.

B.2.2. Natural mortality

New natural mortalities (M) were derived by SMS -runs performed by WGSAM (2019) covering M values for the years 1974–2018. As the SMS will not be updated every year, IBPBASH (ICES, 2020) concluded that further estimates of M will be set in the following way:

- M2019 = M2018 (WGBFAS 2020);

- M2020 and onwards = natural mortality values estimated from the regression of mean M values taken from SMS against Eastern Baltic cod biomass >=20 cm.

B 2.3. Length and age composition of landed and discarded fish in commercial fisheries

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B.3. Surveys

The revised stock abundance estimates from the Baltic International Acoustic Survey (BIAS) were available for the years 1991–2011. The data were revised by WGBIFS experts (further details see Annex H4). The estimates for the years 1993, 1995 and 1997 were excluded due to an incomplete coverage of the standard survey area. There was less than 4% decrease in the recalculated BIAS tuning fleet index for Central Baltic herring in the SD 25–27, 28.2 and 29 due to the corrections made in the database. The BIAS tuning fleet index for Central Baltic herring recruitment in the SD 25–27, 28.2 and 29 has now been area corrected, and a correction of the rectangle assignments was performed. Due to these changes, the herring recruitment indices increased quite substantially in some years (e.g. 1991 and 2002).

Also new BIAS tuning fleet indices for testing with two new Central Baltic herring assessment units were evaluated and provided for benchmark assessment. These new dataseries include the BIAS tuning fleet index (numbers in millions) for Central Baltic herring in the ICES subdivisions 25–27, BIAS tuning fleet index (numbers in millions) for Central Baltic herring in the ICES subdivisions 28.2 and 29, and corresponding recruitment tuning fleets for both of these areas. The internal consistency of these new tuning fleets is worse compared to the BIAS tuning fleet index for Central Baltic herring as one assessment unit.

An alternative dataseries for Central Baltic herring was presented, with the exclusion of the data from the inconsistently covered area of ICES Subdivision 29N. That new tuning fleet had somewhat better internal consistency compared to the ones that include SD29N herring data.

Additionally, the inclusion of the herring acoustic data from SD 32 to the tuning dataseries was tested. The internal consistency of these tuning fleets was very poor, and the inclusion of the SD 32 data would lead to an opposite trend of Central Baltic herring abundance. On this basis, it was decided to postpone the testing of these new tuning fleets, including the acoustic data from SD 32, until the next benchmark assessment of the Central Baltic herring.

Two acoustic time-series were selected for the final assessment of Central Baltic herring: BIAS tuning fleet index for Central Baltic herring in the SDs 25–27, 28.2 and 29 for the years 1991–2011, and BIAS tuning fleet index for Central Baltic herring recruitment (age 0) in the SD 25–27, 28.2 and 29 for the years 1991–2011. For the calculation of these dataseries, all the data from the ICES Subdivision 29 were included. Index values for the years 1993, 1995, and 1997 were excluded from both time-series.

B.3.1. Survey design and analysis

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B.3.2. Survey data used

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B.4. Commercial CPUE

Not used.

B.5. Other relevant data

None.

C. Assessment: data and method

C.1. Choice of stock assess model

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C.2. Model used for basis for advice

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C.3. Assessment model configuration

Model used: XSA

Software used: DOS-XSA/FLR-XSA

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years
Catchability independent on stock size for ages >2

*Catchability independent of age for ages ≥6
Survivor estimates shrunk towards the mean F of the final five years or the three oldest ages

S.E. of the mean to which the estimate are shrunk = 1.500
Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

*correponds in the DOS-XSA setting to ages ≥6 (see benchmark 2013) and in the FLR-XSA setting to qage=6 (the FLR diagnostic output then incorrectly shows >6).

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1974–last data year	1–8+	No
Canum	Catch-at-age in numbers	1974–last data year	1–8+	No
W_{eca}	Weight-at-age in the commercial catch	1974–last data year	1–8+	No
W_{est}	Weight-at-age of the spawning stock at spawning time = WECA.	1974–last data year	1–8+	No
M_{prop}	Proportion of natural mortality before spawning	1974–last data year	1–8+	No
F_{prop}	Proportion of fishing mortality before spawning	1974–last data year	1–8+	No
Matprop	Proportion mature-at-age	1974–last data year	1–8+	No

Natmor	Natural mortality	1974–last data year	1–8+	Yes

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Acoustics	1991–last data year	1–8+

D. Short-Term Projection

Model used: Age structured

Software used: MDFP vers. 1a

Initial stock size: in the 2010 assessment from the XSA for age 2–8+. The recruitment-at-age 1 from RCT3. The long-term geometric mean recruitment for a period of unchanged pattern in recruitment is used for age 1 in all projection years (1988–last data year -1).

Maturity: The same maturity ogives as in the assessment is used for all years

F and M before spawning: Set respectively to 0.3 and 0.35 for all ages in all years

Weight-at-age in the stock: Assumed to be the same as weight-at-age in the catch

Weight-at-age in the catch: Average weight of the three last years.

Natural mortality: Average of the three last years.

Exploitation pattern: Average of the three last years, optional rescaling of F_{bar} (3–6) to the level of the last year, depending on existing or non-existing time-trend in F(3–6) in recent years; Intermediate year assumptions: TAC constraint or *status quo* F or both.

Intermediate year assumptions:

Stock–recruitment model used: None, the long-term geometric mean recruitment-at-age 1 is used.

Procedures used for splitting projected catches: Not relevant.

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E. Medium-Term Projections

Not performed for this stock.

F. Long-Term Projections

Not performed for this stock.

G. Biological Reference Points

The follwing MSY and PA reference points were re-estimated based on the new stock assessment results using the new M values (WGSAM 2019) in 2020 (IPBASH 2020):

Reference Point	Value	Rationale
B_{lim}	330 000 t	The lowest SSB that has given rise to above average recruitment, i.e. year 2002. (The SSB in 2002 also correspond also to B_{loss}).
B_{pa}	460 000 t	1.4* B_{lim}
MSY $B_{trigger}$	460 000 t	B_{pa}
F_{MSY}	0.21	Estimated by EqSim
$F_{MSYUpper}$	0.26	Estimated by EqSim as the upper value of F at 95% of the landings of F_{MSY}
$F_{MSYLower}$	0.15	Estimated by EqSim as the lower value of F at 95% of the landings of F_{MSY}
F_{lim}	0.59	Estimated by EqSim as the F with 50% probability of SSB being less than B_{lim}
F_{pa}	0.32	Following the decision of ACOM in 2021 it was changed during WGBFAS 2021 from former 0.43 into the $F_{p0.5}$ value, which was also calculated during the interbenchmark in 2020 (IPPASH 2020).

H. Other Issues

None.

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